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EXECUTIVE COMMITTEE OF
THE MULTILATERAL FUND FOR THE
IMPLEMENTATION OF THE MONTREAL PROTOCOL
Eightieth Meeting
Montreal, 13-17 November 2017

PROJECT PROPOSAL: MEXICO

This document consists of the comments and recommendation of the Secretariat on the following project proposal:

Refrigeration

• Conversion of domestic refrigeration manufacturing facility from HFC-134a to isobutane (R-600a) as a refrigerant and conversion of compressor manufacturing facility from HFC-134a-based compressors to isobutane-based compressors at Mabe Mexico S.A. de C.V. (Mabe-Mexico)	UNDP

PROJECT EVALUATION SHEET – NON-MULTI-YEAR PROJECT

MEXICO

PROJECT TITLE(S)	BILATERAL/IMPLEMENTING AGENCY
(a) Conversion from HFC-134a to isobutane in the manufacture of domestic refrigerators at Mabe Mexico	UNDP
(b) Conversion of compressor manufacturing facility from HFC-134a-based compressors to isobutane-based compressors at Mabe-Mexico	UNDP

NATIONAL CO-ORDINATING AGENCY	National Ozone Unit/SEMARNAT

LATEST REPORTED CONSUMPTION DATA FOR ODS ADDRESSED IN PROJECT

A: ARTICLE-7 DATA (ODP TONNES, [INSERT YEAR], AS OF [INSERT MONTH AND YEAR])

HFCs	*

B: COUNTRY PROGRAMME SECTORAL DATA (ODP TONNES, [INSERT YEAR], AS OF [INSERT MONTH AND YEAR])

HFCs	*

HFC consumption remaining eligible for funding (ODP tonnes)	n/a

CURRENT YEAR BUSINESS PLAN ALLOCATIONS		**Funding US $**	**Phase-out ODP tonnes**
	(a)	0	0

PROJECT TITLE:	**Mabe-Mexico**	
Project component	**Domestic refrigerator component**	**Compressor component**
HFC-134a used at enterprise (mt):	170.19	n/a
HFC-134a to be phased out (mt):	170.19	n/a
HFC-134a to be phased in (mt CO_2 equivalent):	22,320	n/a
Project duration (months):	24	24
Initial amount requested (US $):	4,500,000	
Final project costs (US $):		
Incremental capital cost:	1,159,988	1,366,167
Contingency (10 %):	108,499	133,617
Incremental operating cost:	1,401,931	n/a
Total project cost:	2,775,940	1,499,784
Local ownership (%):	100	100
Export component (%):	69.35	0
Requested grant (US $):	1,851,824	1,499,784
Cost-effectiveness (US $/kg):	10.88	n/a
Implementing agency support cost (US $):	129,628	104,985
Total cost of project to Multilateral Fund (US $):	1,981,452	1,604,769
Status of counterpart funding (Y/N):	Y	Y
Project monitoring milestones included (Y/N):	Y	Y

SECRETARIAT'S RECOMMENDATION	For individual consideration

*A total of 17,286.66 mt of HFC (including 8,164.20 mt of HFC-134a) was estimated in 2015 (source: ODS survey).

PROJECT DESCRIPTION

1. On behalf of the Government of Mexico, UNDP has submitted a project proposal to convert the manufacturing of domestic refrigerators and compressors at Mabe Mexico, S.A. de C.V. (Mabe-Mexico), from HFC-134a to isobutane (R-600a), at a total cost of US $17,094,016, as originally submitted and associated funding request from the Multilateral Fund of US $4,500,000, plus agency support costs of US $315,000.

Project objective

2. The project will eliminate the annual consumption of 170.19 mt (243,371 CO_2 tonnes) of HFC-134a at six lines manufacturing domestic refrigerators at Mabe-Mexico; and will convert production of compressors that work with HFC-134a as refrigerant to R-600a. The energy efficiency of the domestic refrigerators is estimated to improve by about 16 per cent through modifications of the components and in line with requirements under National Official Standards (NOM-15).

HFC consumption and sector background

3. In 2015, 17,286.66 mt of HFCs were consumed in the refrigeration and air-conditioning (RAC) sector in Mexico. Table 1 presents the sector distribution of consumption of HFCs.

Table 1. HFC consumption in the RAC sector in 2015 (mt)*

Sectors	HFC-134a	R-404A	R-407C	R-410A	R-413A	Others	Total
Refrigeration							
Manufacturing	1,310.29	413.14			469.26	90.75	2,283.44
Servicing	1,480.34	316.10			175.99	92.25	2,064.68
Air-conditioning							
AC manufacturing	327.78		69.29	6,667.02			7,064.10
Mobile AC	4,589.25						4,589.25
AC servicing	166.09		82.62	316.92		5.61	571.23
Chiller Manufacturing	265.00			349.73			614.73
Chiller servicing	25.45		4.70	69.08			99.23
Total	**8,164.20**	**729.24**	**156.61**	**7,402.76**	**645.25**	**188.60**	**17,286.66**
% consumption in mt	**47.2**	**4.2**	**0.9**	**42.8**	**3.7**	**1.1**	**100.0**
% consumption in CO_2-equivalent	**25.3**	**8.9**	**0.9**	**47.9**	**4.1**	**13.0**	**100.0**

*As reported in the survey of ODS alternatives.

Domestic refrigerator market

4. There are three domestic refrigerator manufacturing enterprises that cater to about 63 per cent of the market in Mexico. The capacity of the equipment ranges from 210 litres to 520 litres. Table 2 provides total domestic market refrigerator production and sales in Mexico.

Table 2. Market of domestic refrigerators in Mexico (in units)

Particulars	2010	2011	2012	2013	2014	2015	2016
Production	7,009,900	7,220,197	7,436,803	7,659,907	7,889,704	8,126,395	8,410,819
Import	597,376	615,297	633,756	652,769	672,352	692,523	716,761
Export	5,976,733	6,156,035	6,340,716	6,530,938	6,726,866	6,928,672	7,171,176
Total domestic sales	**1,630,543**	**1,679,460**	**1,729,843**	**1,781,738**	**1,835,190**	**1,890,246**	**1,956,404**
R-600a based units							

Particulars	2010	2011	2012	2013	2014	2015	2016
Production			293,833	302,648	615,166	499,000	513,960
Import							
Export			293,833	302,648	499,000	499,000	513,960

5. In 2016, about 8.41 million domestic refrigerators were manufactured in Mexico; 85.2 per cent of this production were exported and 716,761 refrigerators were imported. Of the total production for domestic sales, approximately 79.2 per cent are HFC-134a-based and 20.8 per cent are R-600a-based. Details of number of manufacturers producing R-600a based domestic refrigerators is not available.

Enterprise background

6. Mabe-Mexico is one of the largest producers of domestic refrigerators[1] and has Mexican and Chinese ownership.

7. At the 15th meeting, Mabe-Mexico received funding to convert its two domestic refrigerator manufacturing lines (i.e., from CFC-12 to HFC-134a and from CFC-11 to HCFC-141b). At the same meeting, Mabe-Mexico received funding for conversion of their domestic refrigerator CFC-12 compressor manufacturing facility to manufacture HFC-134a-based compressors. These projects were completed in September 1997.

8. At the 59th meeting, Mabe-Mexico received additonal assistance to convert its manufacturing capacity from HCFC-141b used in insulation foam to cyclopentane. The project has completed resulting in the phase-out of 354 mt (38.94 ODP tonnes) of HCFC-141b and 306 mt (16.83 ODP tonnes) of HCFC-22.

HFC consumption by the enterprise

9. Mabe-Mexico produces six models of domestic refrigerators using HFC-134a at its six production lines which are located in the same facility and have similar layout and installed capacity. Of the six production lines, two lines have capacity to produce R-600a-based domestic refrigerators. The compressor manufacturing facility is also located in the same location.

10. Table 3 presents the 2014-2016 production of HFC-134a-based domestic refrigerators at Mabe Mexico.

Table 3. Capacity and sales of Mabe-Mexico refrigerators

Year		Production (units)	
	HCFC-134a (mt)	Total	Export to non-Article 5 countries
2014	133.96	1,189,892	391,772
2015	158.07	1,405,817	435,792
2016	170.19	1,507,453	462,097
Average consumption	**154.07**		
Average consumption (CO_2 tonnes)	**220,320**		

Selection of alternative technology

11. R-600a was selected as the alternative technology as it has an energy efficiency advantage over HFC-134a, and has zero ODP and very low-global warming potential (GWP). Further, this technology is

[1] The enterprise has production and commercial operations in Argentina, Brazil, Canada, Central America, Chile, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Venezuela (Bolivarian Republic of).

currently in use in Mexico with adequate supply of refrigerant gas and components. The markets in Latin American are moving towards R-600a domestic refrigerators.

Project description

Domestic refrigerator manufacturing

12. Given the flammability of R-600a, changes are required in the production process mainly at the four out of six manufacturing lines, in the end-products, and modifications in material flow operations to work with HC-based refrigerants. The project contains three components for which funds are requested:

(a) Modifications to the storage and supply of refrigerant, including explosion proof pumping and pipeline system to download, store and distribute the refrigerant at the plant; a storage tank; a safety system (i.e., leak detectors, fire-fighting equipment, shut-off valves and flux and pressure sensors, water sprinkler, smoke detectors); equipment installation and civil works (i.e., construction of pump and transfer rooms); and relevant certifications (US $592,923);

(b) Production line modifications including introduction of helium leak detection equipment; four refrigerant charging stations suitable for R-600a and retrofitting of one existing charging station; three ultrasonic sealing of the refrigeration system; five post-charge leak detectors; safety system and certification based on local standards in the manufacturing process and repair zone; civil works; costs of modification of tools, and material handling facilities (US $1,471,396); and

(c) Modifications to the laboratory for development and testing; modifications to the electrical controls of the HC-based fridges to ensure safe operation; installation and start-up of all the new equipment modifications and engineering component changes; and electronic components of manufacturing facilities including electronic cards and harness (US $897,566).

Project costs and co-financing

13. The incremental capital costs (ICC), as originally submitted and including contingencies, were at US $3,258,074 as shown in Table 4.

Table 4: Costs for the conversion of domestic refrigerators to R-600a in Mabe-Mexico

Description	**Cost (US$)**	**%**
Supply system R-600a (tank + facilities + pump room)	370,783	11.4
Safety systems R-600a (tank + facilities)	222,140	6.8
Charging equipment, tube sealed and leakage detection in process areas	480,282	14.7
Safety systems and charging and leakage area facilities	311,461	9.6
Helium leakage detection systems for evaporator and high side	399,460	12.3
Charging area room (flame-free and electrical components)	90,962	2.8
Working station enabling (assembly and cabinet)	189,231	5.8
Modification of liners die cutters and foam moulds	34,570	1.1
Secondary facilities (air, nitrogen and electricity) node network	139,972	4.3
Material flow (containers and backup cars)	178,011	5.5
Die cutters for back recess and lid (back up electronic card)	260,000	8.0
Electronic cards (equipment and devices)	186,000	5.7
Harness (routing board)	99,013	3.0
Sub-total	**2,961,885**	**90.9**
Contingencies (10 %)	296,189	9.1
Total	**3,258,074**	**100.0**

14. As the baseline equipment varied for each line, the requested funding for some of the lines were lower than the other lines; for example, one line had refrigerant charging equipment, HC leak detection equipment and helium leak detector and as a result funding was not required for these equipment items. Further, some of the equipment items appear to relate to material flow modifications and engineering tools that may be not be incremental for the conversion project.

15. Incremental operating costs (IOC) which includes costs related to change in refrigerant and energy efficiency improvement was estimated at US $3.82 per unit on an average excluding compressors for conversion of refrigerant to R-600a, and US $2.54 per unit on an average for energy efficiency component. Funding requested for total IOC for one year is US $7,744,980, as shown in Table 5.

Table 5. IOC for domestic refrigerator manufacturing in Mabe-Mexico

Models	R-600a (US $)	Energy efficiency (US $)	Total (US $)
One door (A210)	46,428	30,952	77,380
No Frost (230 L to 300 L)	1,973,400	1,315,600	3,289,000
No Frost 360 L	777,240	518,160	1,295,400
No Frost (400 L to 520 L)	853,440	568,960	1,422,400
BF Pangea	435,960	290,640	726,600
SXS	560,520	373,680	934,200
Total	**4,646,988**	**3,097,992**	**7,744,980**

Compressor manufacturing

16. Mabe-Mexico also has compressor manufacturing facilities with a total capacity of 1.5 million compressors per annum producing two different categories of compressors namely CQ (30 to 100 watts) and CB (90 to 140 watts).

17. The conversion of compressor manufacturing involves retrofitting manufacturing lines, quality-testing equipment, tooling for new parts, product development and modification in testing facilities including calorimeter, at a total estimated cost of the product is US $6,090,962 as shown in Table 6.

Table 6: Costs for conversion to R-600a compressors at Mabe-Mexico

Description	Cost (US $)	%
Retrofit of existing manufacturing lines	**3,552,844**	**58.3**
Monoblock line	628,672	
Crankshaft line	864,369	
Connecting rod line	237,125	
Valve plate line	415,394	
Piston line	270,935	
Assembly line	479,183	
Rotor line	33,131	
Stator line	624,035	
Quality test equipment	**460,576**	**7.6**
New parts tooling	**445,684**	**7.3**
Prototypes and tools	**77,482**	**1.3**
Product development	**567,884**	**9.3**
Calorimeters	**432,768**	**7.1**
Subtotal	**5,537,238**	**90.9**
Contingencies (10%)	**553,724**	**9.1**
Total	**6,090,962**	**100.0**

18. The project also includes co-financing. UNDP has indicated that they have assured grants under Kigali Cooling Efficiency Program (KCEP) amounting to US $400,000, which is available once the project

is prepared with completely assured funding. Additional co-financing amounting to US $8,564,008 would be provided by Mabe-Mexico.

19. The summary of the total project funding including adjustments for exports to non-Article 5 countries and co-financing, is given Table 7.

Table 7. Total project funding request for Mabe-Mexico (as submitted)

Component	Costs in US $
Incremental cost for refrigerator manufacturing	11,003,054
Incremental cost for compressor manufacturing	6,090,962
Total	**17,094,016**
Adjustment for export to non-Article 5 countries for refrigerator manufacturing (33 per cent)	(3,631,008)
Adjusted incremental costs	**13,463,008**
Co-financing from KCEP	(400,000)
Co-financing from enterprise and other sources	(8,563,008)
Requested funding	**4,500,000**

20. The cost-effectiveness of the project for the conversion of the refrigerator manufacturing lines (excluding the compressor lines) is US $64.65/kg. The project will be implemented over a period of 24 months.

SECRETARIAT'S COMMENTS AND RECOMMENDATION

COMMENTS

Eligibility

21. The Secretariat reviewed the project proposal based on the current policies and decisions of the Multilateral Fund, similar approved conversion projects for CFC phase-out (i.e., conversion of refrigerant component from CFC-12 to R-600a involving product and manufacturing process redesign, conversion of compressor manufacturing plants from ODS to flammable alternatives) and approved projects to phase-out ODS with flammable alternatives.

22. The project for Mabe-Mexico has been submitted in line with decisions 78/3(g) and 79/45. It included an official letter from the Government with the commitment required in decision 78/3(g). In line with decision 79/45, the endorsement letter from the Government of Mexico indicates it would make every effort to ratify the Kigali Amendment, as soon as possible, confirmed that it is aware that no further funding would be available until the instrument of ratification of the Kigali Amendment had been received by the depositary at the United Nations Headquarters in New York, if this project would be approved by the Executive Committee; and acknowledged that in case this project is approved, any HFC reduced would be deducted from its starting point (which may be agreed in the future). The Secretariat also notes with appreciation that this proposal was submitted without preparation funding.

23. UNDP explained that Mabe-Mexico and the Government are strongly committed to implement this project; this is reflected in the significant levels of co-financing that the enterprise proposes to invest for implementing this project; the enterprise also intends to use this conversion project for achieving energy efficiency standards in the country. The results of the project are expected to encourage adoption of energy efficient R-600a-based equipment in the markets in Mexico and in the region.

Regulatory framework

24. The Secretariat requested clarifications on how sustainability of production of R-600a-based refrigerators would be achieved noting that R-600a-based refrigerators are just being introduced in the market and have a share of 6.2 per cent in the total production in the country. UNDP explained that the Government has implemented nine standards that relate to energy efficiency and safety for production and sales of R-600a-based domestic refrigerators; further, Mabe-Mexico has decided to adopt R-600a technology to comply with the national energy efficiency regulations which would require refrigerators to increase their energy efficiency on average of 16 per cent; this will also help the enterprise sell in other markets which are implementing higher energy efficiency standards for refrigerators. The Secretariat also noted that the R-600a-based refrigerator production has increased since 2012.

Proposed costs

25. The Secretariat requested clarification on the need and costs for charging equipment, helium leak detectors, ultrasonic welding machine, HC leak detector, HC recovery machine, and other equipment that were for distribution of components, quality control and information technology support, noting that some of these costs do not appear to be incremental for the proposed conversion project. The Secretariat also asked clarifications on what components of the project would be co-financed by the enterprise.

26. UNDP explained that the requested modifications were necessary to implement the conversion project noting that the enterprise has already undertaken initial steps such as product design modifications and conversion of some of the refrigerator assembly lines. UNDP agreed to adjust costs required for refrigerant charging equipment, ultrasonic welding machines in the production lines, helium leak detection equipment, some of the costs relating to storage and gas supply systems, and costs relating to safety equipment. Additional costs for technical assistance and safety audit and training amounting to US $75,000 were included in the incremental capital costs. UNDP also explained that the enterprise has not specifically identified individual components that would be co-financed but would be providing additional finance beyond the agreed costs for implementing the conversion project.

27. The Secretariat also requested clarification on the methodology followed for calculating the IOC (i.e., how the energy efficiency component and refrigerant conversion components were separately identified) and noted that IOC was higher than the costs of similar projects submitted to the 80th meeting. UNDP provided details of IOC calculations for individual models and explained that a proportion of the total incremental costs was applied to refrigerant conversion (60 per cent) and energy efficiency component (40 per cent). Based on discussions and inputs on comparable projects with similar refrigerator conversion requirements from the region, UNDP agreed to rationalise the IOC from US $6.36 to US $0.93 per unit on an average. Incremental costs for compressor was also removed as the project includes conversion of compressor manufacturing facility in the enterprise.

28. The agreed costs of the conversion of the domestic refrigerator manufacturing lines are shown in Table 8.

Table 8. Agreed costs for conversion of domestic refrigerator manufacturing at Mabe-Mexico

Particulars	Proposed cost (US $)	Agreed cost (US $)
Refrigerator manufacturing		
Product design, testing and certification	-	-
Refrigerant charging and supply system	370,783	260,000
Assembly line modifications	1,966,539	562,988
Safety systems	624,563	262,000
Subtotal	**2,961,885**	**1,084,988**
Contingency (10%)	296,189	108,499
Technical assistance and safety audit	0	60,000

Particulars	Proposed cost (US $)	Agreed cost (US $)
Training	0	15,000
Total capital cost	**3,258,074**	**1,268,487**
Incremental operating costs	7,744,980	1,401,931
Total cost before adjustment for exports to non-Article 5 countries	**11,003,054**	**2,670,418**
Adjustment for exports to non-Article 5 countries*	(3,631,008)	(818,594)
Total incremental costs	**7,372,046**	**1,851,824**
HFC-134a consumption (mt)	**170.19**	**170.19**
CE (US $/kg)	**43.32**	**10.88**

*Exports to non-Article 5 countries amount is 30.65 per cent of total production.

Conversion project for compressors

29. The Secretariat has limited experience in projects related to the conversion of compressor manufacturing from HFC-134a to isobutane for domestic refrigerators; however, it reviewed this project in light of the demonstration projects approved for compressor conversion to HC refrigerant in air-conditioning and discussions relating to compressor conversion project for Bangladesh submitted to the 80th meeting[2], noting similarities between these projects.

30. The proposed conversion is for producing fixed-speed isobutane-based compressors. UNDP explained that the choice of fixed-speed compressor model was to provide a cost advantage. The conversion of the compressor to variable speed design would be undertaken based on market demand for such equipment at a future date.

31. The Secretariat requested clarification on the costs associated with changes in the manufacturing facility, and the costs associated with product redesign noting that the enterprise has already developed product designs, testing facilities and technical assistance costs.

32. Further to discussion with UNDP, it was agreed to adjust the costs for plant equipment modification from US $3,998,528 to US $1,086,167; costs of testing from US $893,344 to US $250,000, and allocate US $30,000 for technical assistance. The agreed costs for conversion of the compressor manufacturing facility are shown in Table 9.

Table 9. Agreed costs for conversion of compressor manufacturing at Mabe-Mexico

Particulars	Proposed cost (US $)	Agreed cost (US $)
Costs of plant equipment modification	3,998,528	1,086,167*
Product redesign and prototype development	645,366	-
Product testing and quality control	893,344	250,000
Subtotal	**5,537,238**	**1,336,167**
Contingency (10%)	553,724	133,617
Technical assistance		30,000
Total	**6,090,962**	**1,499,784**

**Including delivery and installation costs.*

Agreed level of funding

33. Based on the above review, the proposed incremental costs for conversion for the refrigerator manufacturing component of Mabe-Mexico amounts to US $3,351,607 to phase out 170.19 mt (308,044 CO_2-tonnes) of HFC-134a as shown in Table 10. UNDP informed that additional funding required for conversion will be co-financed by the enterprise and/or obtained from other funding sources.

[2] UNEP/OzL.Pro/ExCom/80/32.

Table 10. Agreed incremental costs for conversion of refrigerator and compressor manufacturing at Mabe-Mexico

Particulars	HFC-134a phase-out (mt)	Cost (US $)	Cost–effectiveness (US $/kg)
Refrigerator manufacturing	170.19	1,851,824	10.88
Compressor manufacturing	-	1,499,784	n/a
Total	**170.19**	**3,351,608**	**n/a**

34. The Secretariat notes that the purpose of implementing projects under decision 78/3(g) is to gain experience in the ICCs and IOCs that might be associated with phasing down HFCs. Based on available information at the time of review, the Secretariat considers that the agreed costs are its best estimates of the overall incremental costs of conversion; these estimates might change as more information becomes available, and according to the specific characteristics of the enterprises. The Secretariat, therefore, considers that the agreed costs above would not constitute a precedent.

35. The enterprise has committed that it will stop using HFC-134a in producing domestic refrigerators upon project completion by December 2019.

2017-2019 Business plan

36. This project does not fall under the regular business plans submitted to the Secretariat and presented to the Executive Committee as it falls under the purview of decision 78/3(g).

RECOMMENDATION

37. The Executive Committee may wish to consider the project for conversion of domestic refrigeration manufacturing facility from HFC-134a to isobutane (R-600a) as a refrigerant and conversion of compressor manufacturing facility from HFC-134a-based compressors to isobutane-based compressors at Mabe Mexico S.A. de C.V. in the context of its discussion of the proposals for HFC-related projects described in the document on Overview of issues identified during project review (UNEP/OzL.Pro/ExCom/80/22).